

ACTS Rain Fade Compensation

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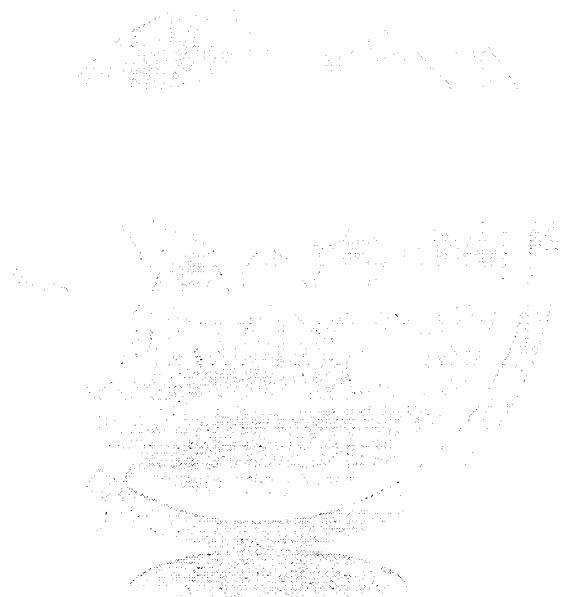
NASA Lewis Research Center
Cleveland, Ohio

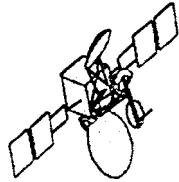
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VSAT Architecture Outdoor Unit

- ◆ 2.4/1.2 meter offset fed parabolic dish
- ◆ 12 watt transmitter
 - Solid state frequency doubler
 - 50 W Ku band TWTA driver



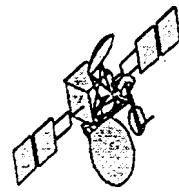


VSAT Architecture

Indoor Unit

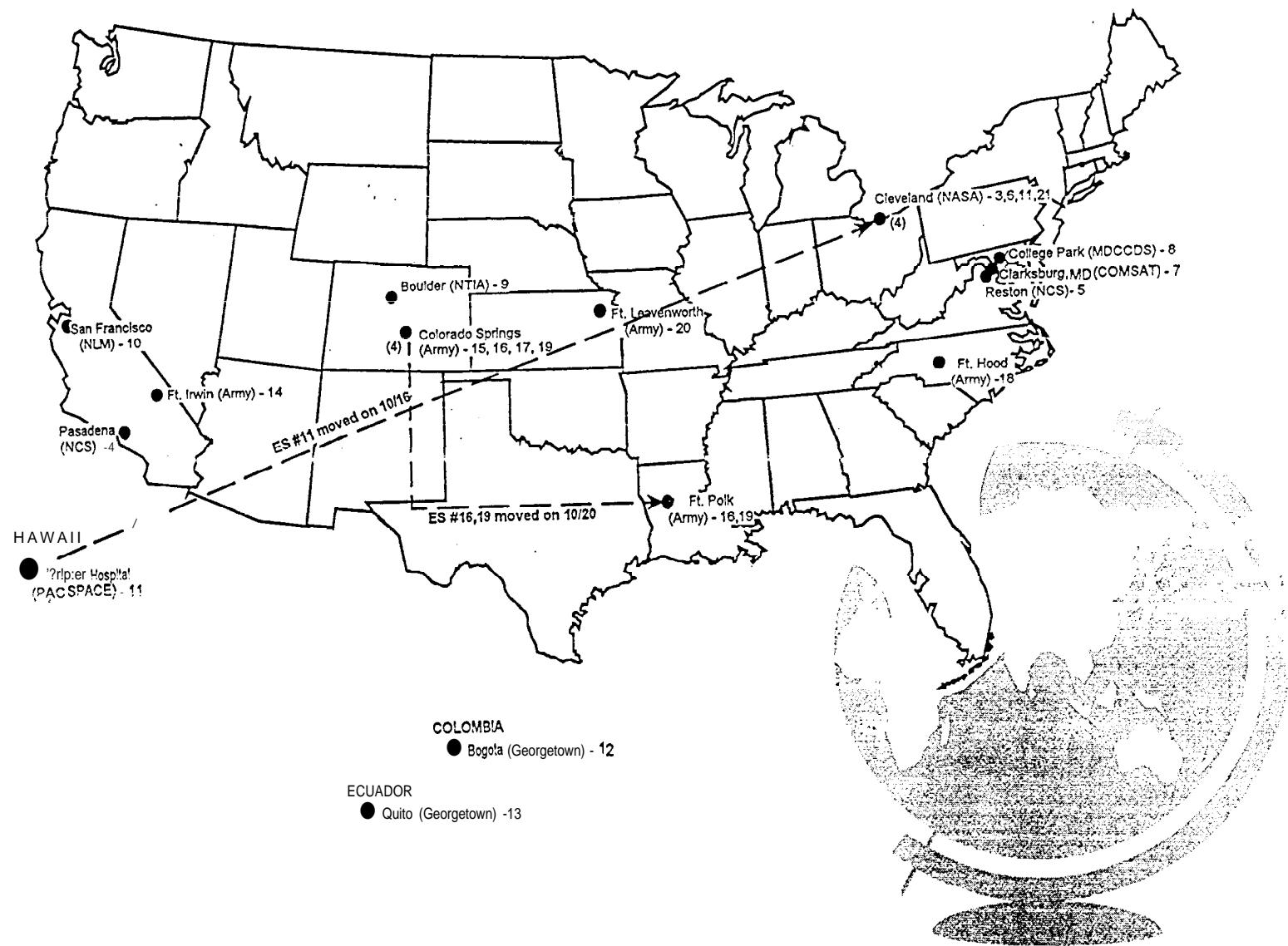
- ◆ Control Processor
- ◆ TDMA Hardware
- ◆ SMSK Modem
- ◆ Public Switched Network (PSN)
Compatible Terrestrial Interface
- ◆ 1.792 Mbps Throughput (28 -64 k b p s circuits)

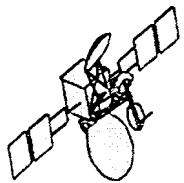




VSAT Locations

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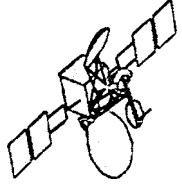




Link Margins

VSAT ID	Beam	Antenna Size	Uplink Margin	Downlink Margin
3	West	2.4m	≥ 11 dB	4.7-7.7 dB
13	West	2.4m	≤ 1.0 dB	4.0 dB
9	West	1.2m	≈ 5.3 dB	3.8-6.7 dB
5	East	1.2m	≈ 3.0 dB	3.8-5.0 dB
7	East	2.4m	≈ 3.3 dB	2.0-4.7 dB
8	East	2.4m	≥ 11 dB	6.0-7.3 dB

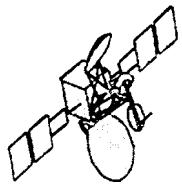
Uplink and downlink BER performance in clear sky conditions is typically $3.3E-10$ excluding the fast varying thermal period.



Rain Fade Algorithm Characterization

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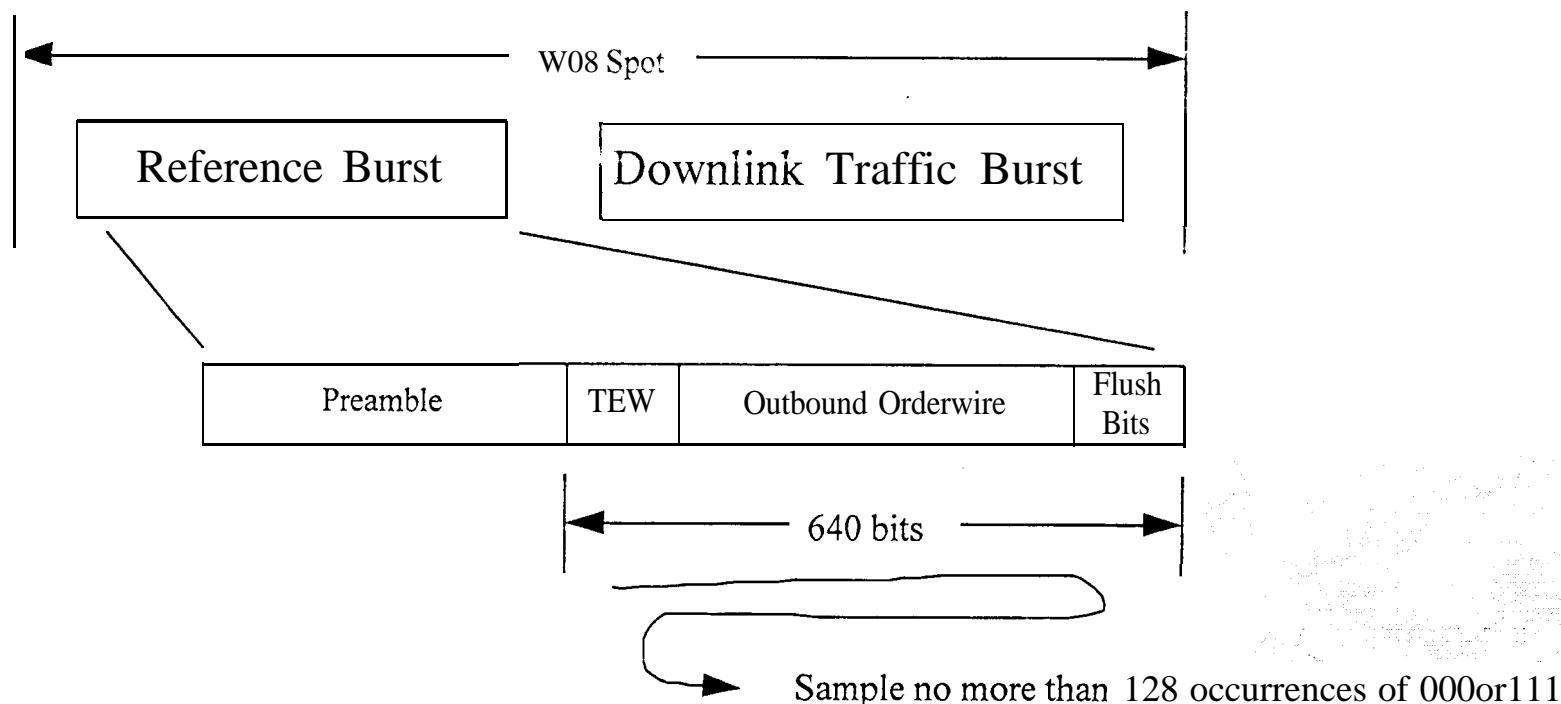
- ♦ Validate VSAT Downlink Signal Measurement
- ♦ Measure Rain Fade Availability for VSATS
 - + Measure BER Availability for VSATS
- ♦ Measure Performance as a Function of Fade Rate

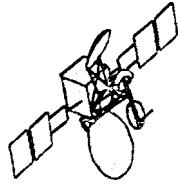


Downlink Signal Level Estimation

- ♦ Sample the VSAT demodulator output voltage of the center bit of 1's and 0's triplets

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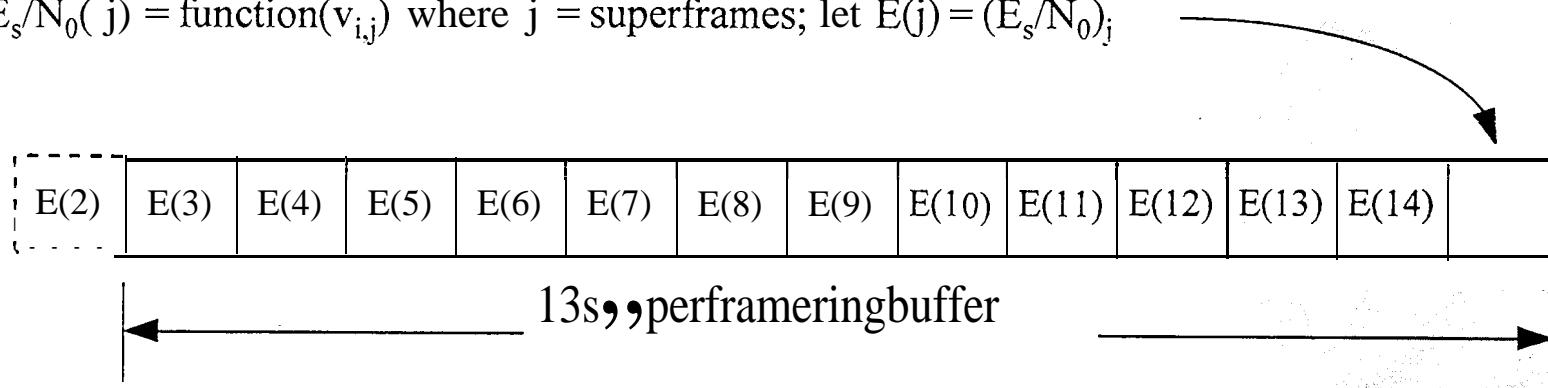


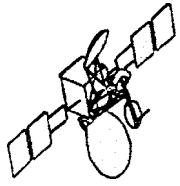
Downlink Signal Level Estimation

- Accumulate 128 samples, v_i , from each of the 75 frames in a superframe; i.e. $i = 9600$
- Estimate E_s/N_0 from the 9600 samples using the mean to variance method and store in a ring buffer

05†

$E_s/N_0(j) = \text{function}(v_{i,j})$ where j = superframes; let $E(j) = (E_s/N_0)_j$





Downlink Signal Level Estimation

- e Calculate the 1 second (13 superframe) running average of E(j) thru E(j+12) and report to the Master Control Station every 2 to 13 superframes.

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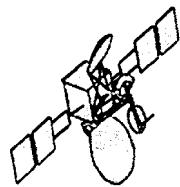
E(3)	E(4)	E(5)	E(6)	E(7)	E(8)	E(9)	E(10)	E(n)	E(12)	E(13)	E(14)	E(15)
------	------	------	------	------	------	------	-------	------	-------	-------	-------	-------

Average E(3) thru E(15) = Estimated E_s/N_0 → MCS

E(5)	E(6)	E(7)	E(8)	E(9)	E(10)	E(n)	E(12)	E(13)	E(14)	E(15)	E(16)	E(17)
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Average E(5) thru E(17) = Estimated E_s/N_0 → MCS

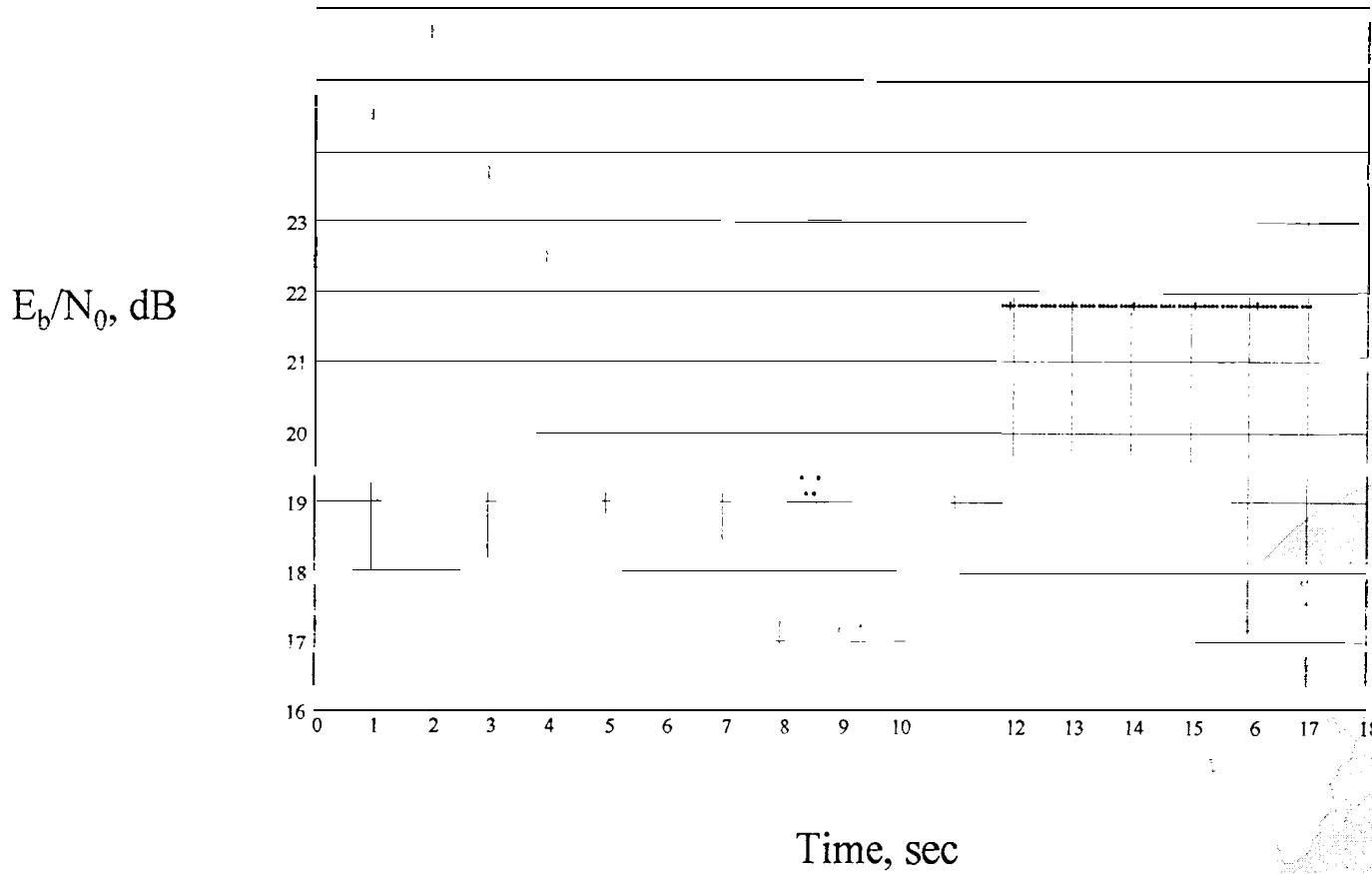




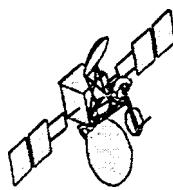
Measurement Impact of 1 Sec. Running Average

Fade Duration - 1 sec., Fade Rate - 3 dB/sec

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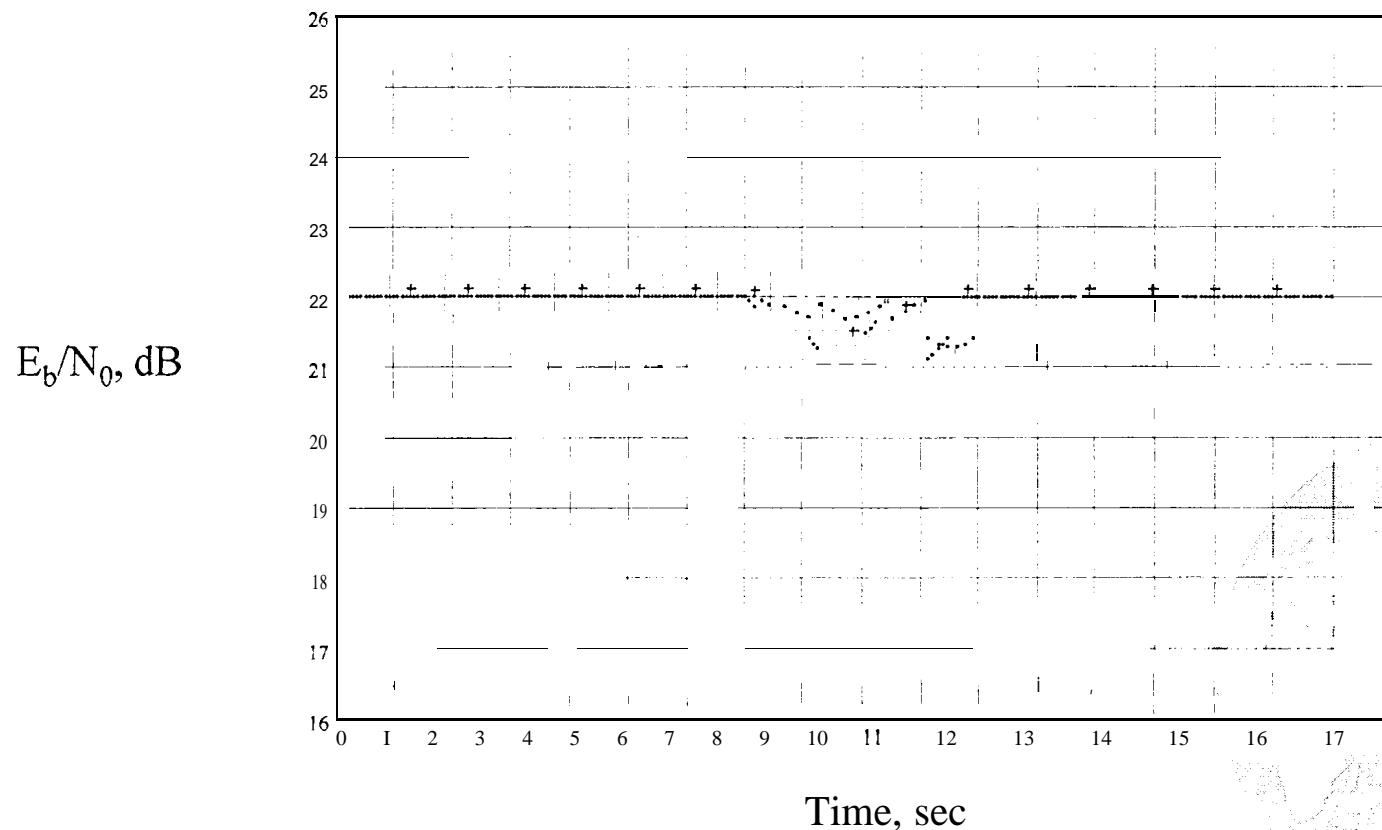
+ 1 sec. average of 150 ms data



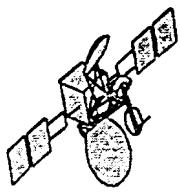
Measurement Impact of 1 Sec. Running Average

Fade Duration -1 sec., Fade Rate -1 dB/sec

453



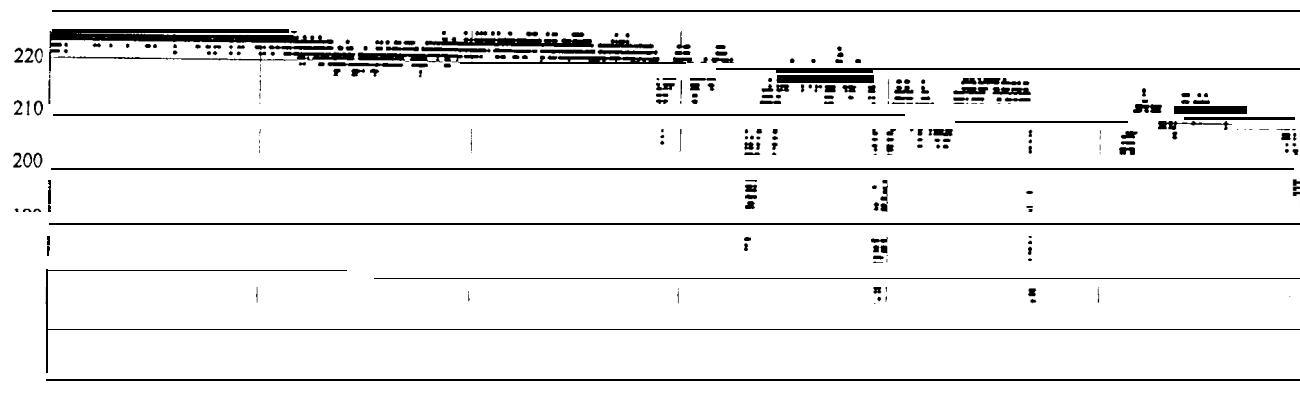
+ 1 sec. average of 150 ms data



150 ms Fade Data for VSAT #7, 1/20/95

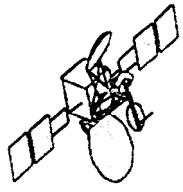
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Signal Level,
(1 - 254)*



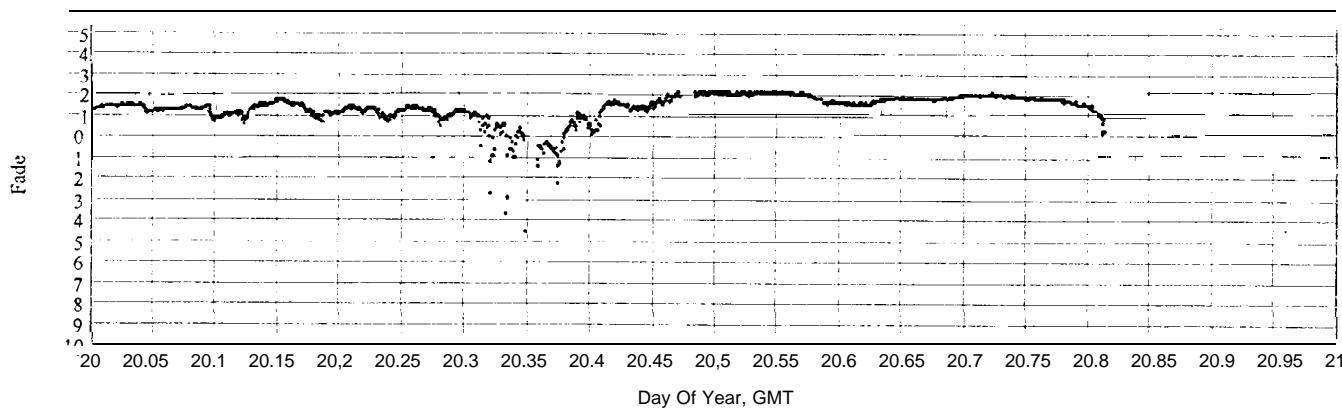
* 5 dB per unit

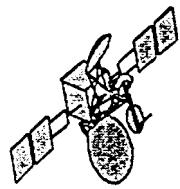




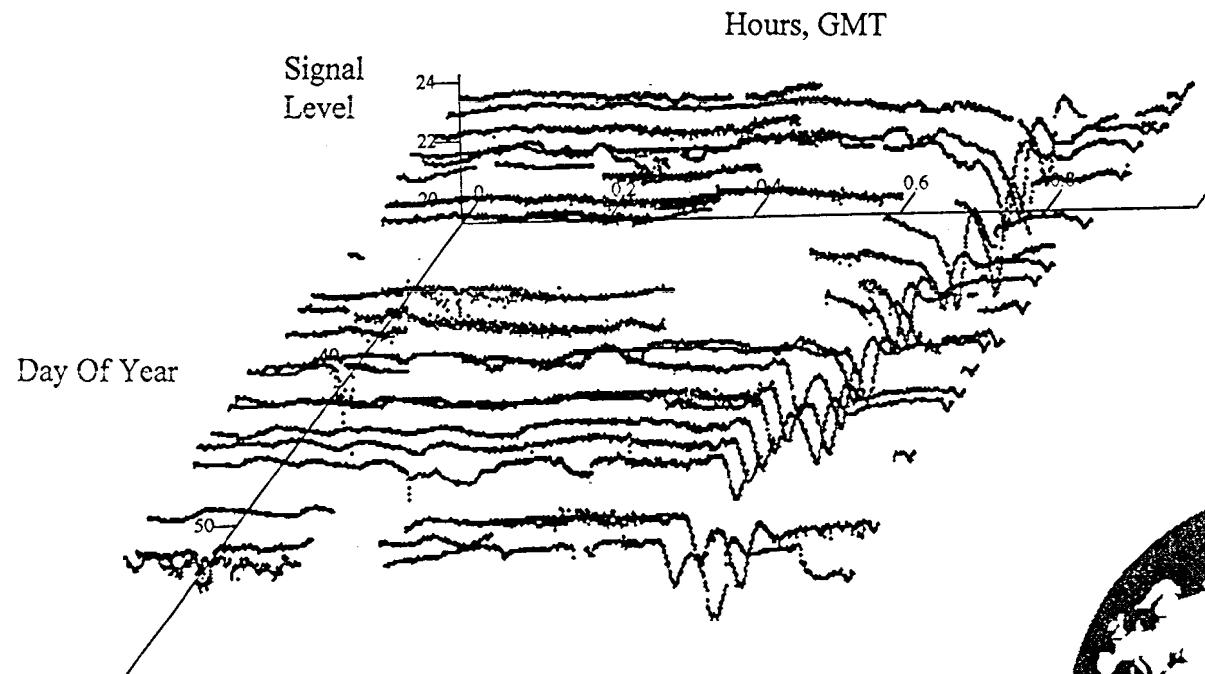
1 min. Fade Data for VSAT #7, 1/20/95

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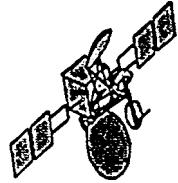


1 min Fade Data for VSAT #7, Feb., 995

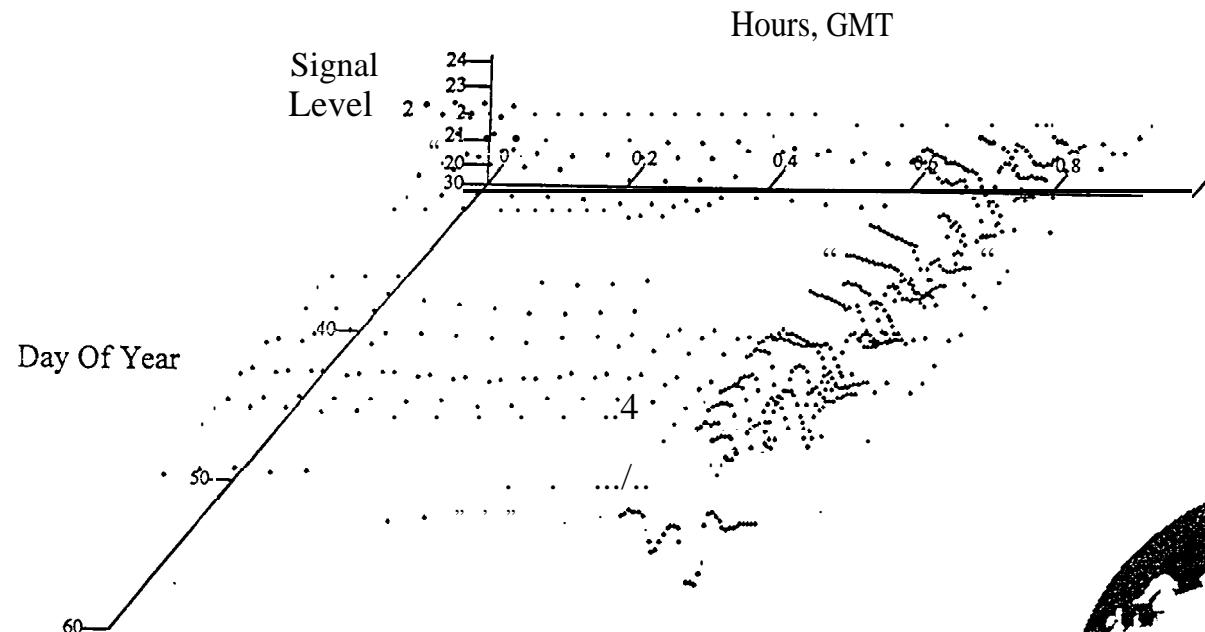


(The variations in signal level in the 1700 - 2300 GMT period is the result of beam mispointing which is in turn caused by thermal effects on the spacecraft antenna.)



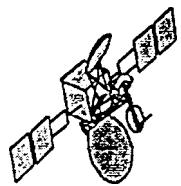


Filtered Fade Data for VSA'T #7, Feb., 1995

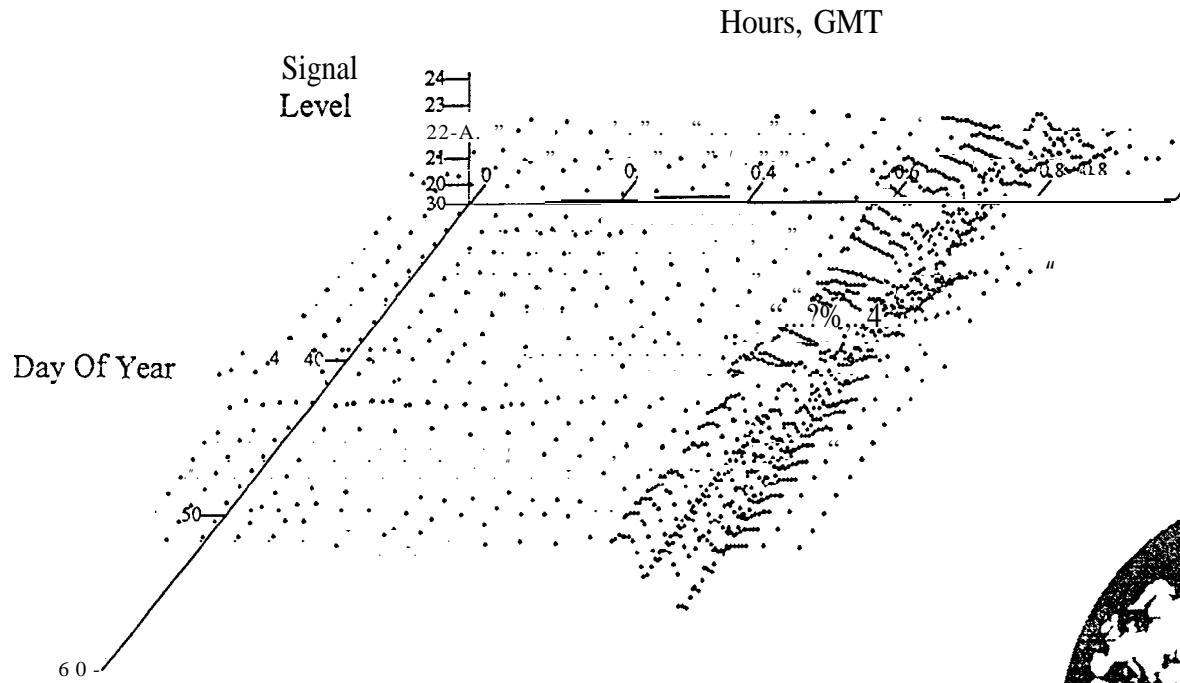


The data is filtered by standard deviation selecting
only "clear sky data."



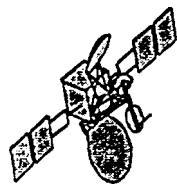


Interpolated Fade Data for VSAT #7, Feb., 1995



The filtered data is linearly interpolated across days so as to estimate the month's clear sky signal levels.

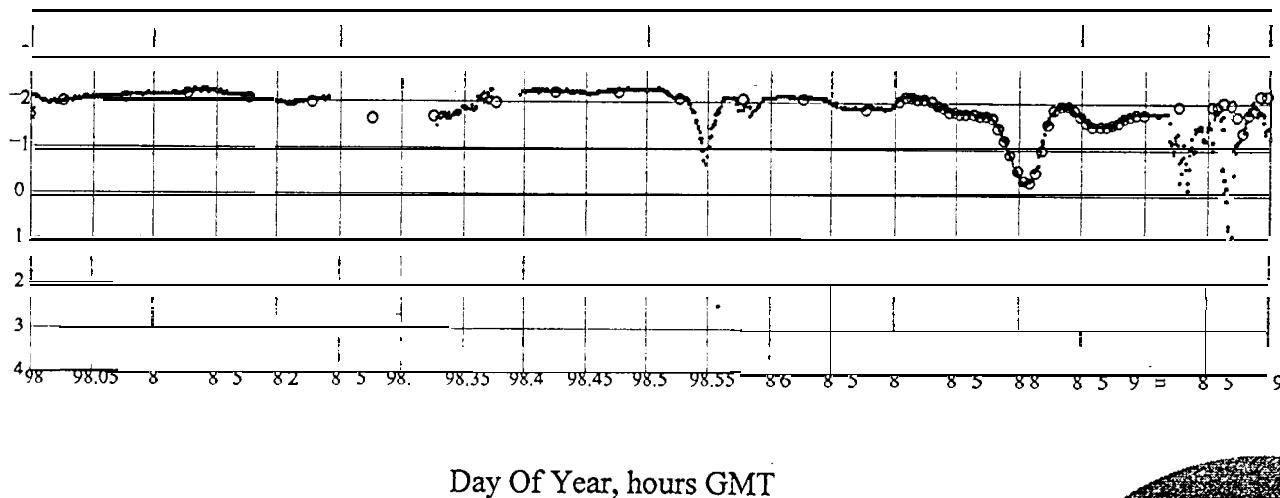




Fade Data and Clear Sky Baseline Fit

Downlink
Signal, dB

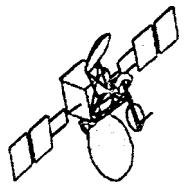
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- clear sky baseline
- fade data

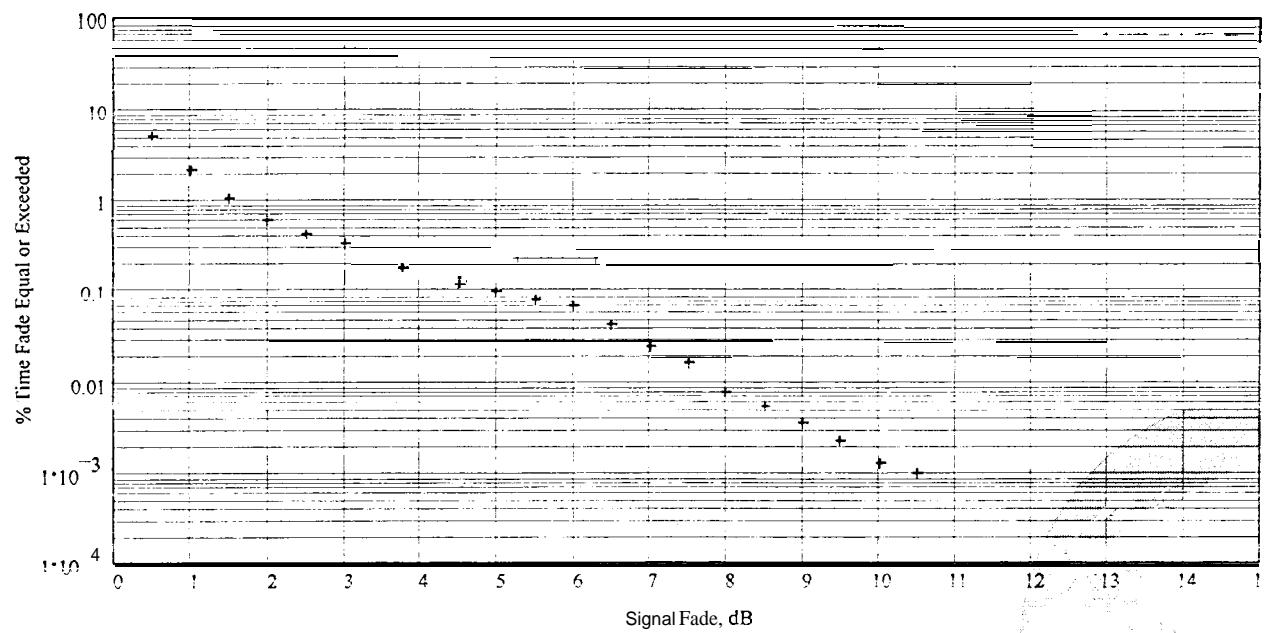
The signal level data is then subtracted from the estimated clear sky levels to yield the signal fade.

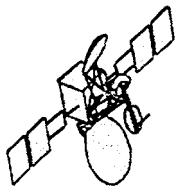




Fade Availability for VSAT #7 1995

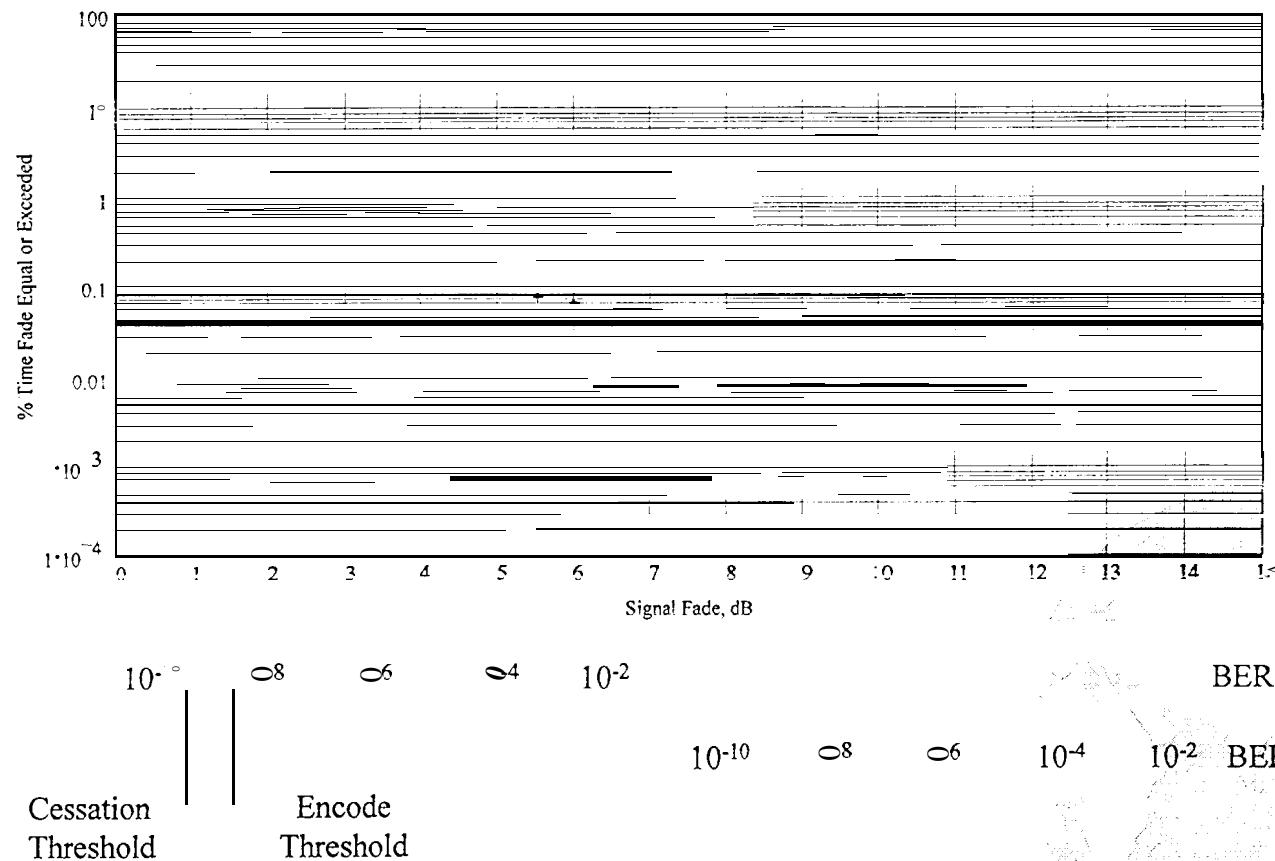
460

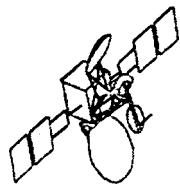




461

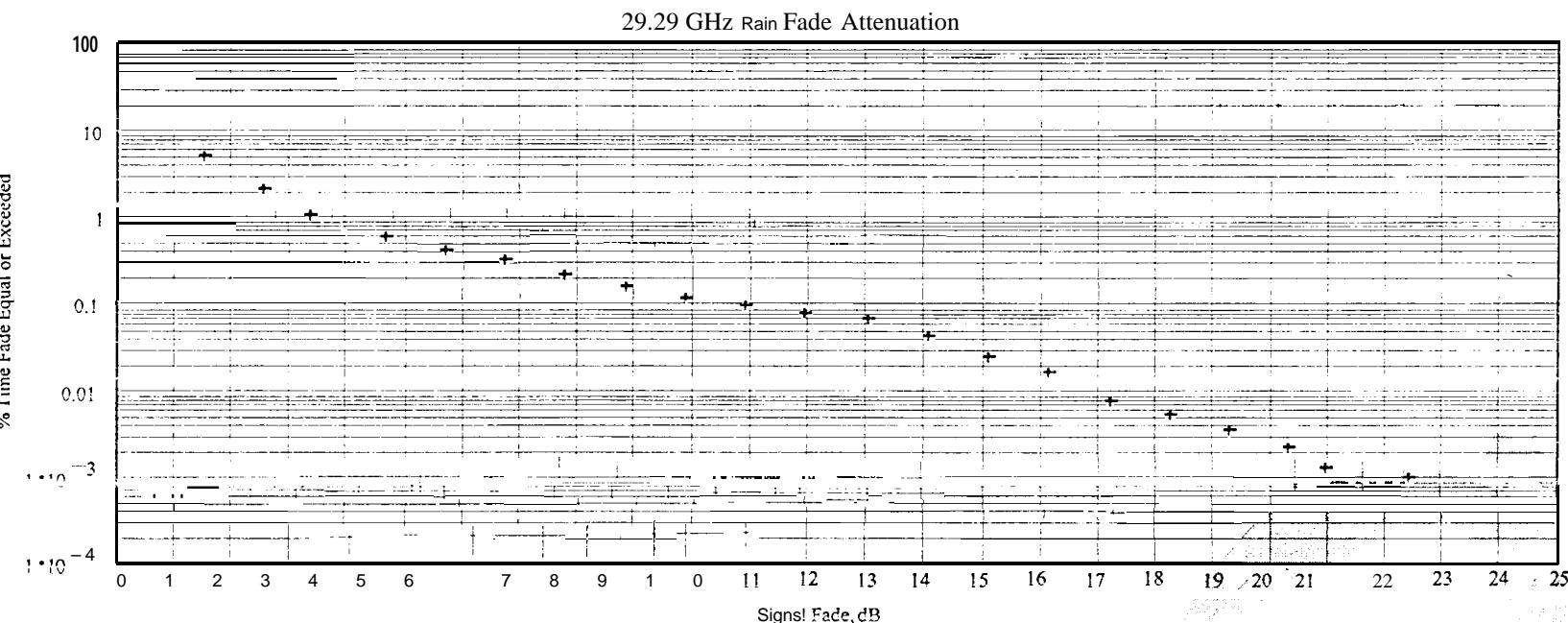
Downlink BER Availability for VSAT #7, 1995





Estimated Uplink BER Availability for VSAT #7, 1995

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10⁻¹⁰ 10⁻⁸ 10⁻⁶ 10⁻⁴ 10⁻²

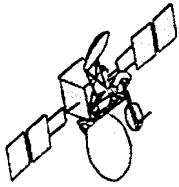
Cessation Threshold : Encode Threshold

10⁻¹⁰ 10⁻⁸ 10⁻⁶ 10⁻⁴

BER Uncoded

10⁻²

BER Coded



Performance Status

Adaptive Rain Fade Compensation

- ◆ The rain fade protocol is functional detecting fades, providing an additional 10 dB of margin and seamless transitions to and from coded operation
- ◆ The stabilization of the link margins and the optimization of rain fade decision thresholds has resulted in improved BER performance
- ◆ Characterization of the Fade Compensation Algorithm is Ongoing

